Chapter 3
WATER RESOURCES AND SYSTEM OVERVIEW

REGIONAL HYDROLOGIC CYCLE

The main components of the hydrologic cycle in the UEC Planning Area are precipitation, evapotranspiration, surface water inflow and outflow, and ground water flow.

Precipitation and Evapotranspiration

The 52-year average rainfall in the planning area is about 51 inches per year, but varies considerably from year to year (Figure 7). There is a wet season from May through October, and a dry season from November through April. The maximum monthly average rainfall is 7.52 inches in September (St. Lucie County) and the minimum monthly average rainfall is 1.93 inches in December (Martin County). Monthly rainfall displays a higher measure of relative variability during the dry period. Rainfall also varies areally (from location to location), with rainfall amounts generally decreasing from east to west. Historical rainfall data and the results of a frequency analysis are presented in Appendix C.

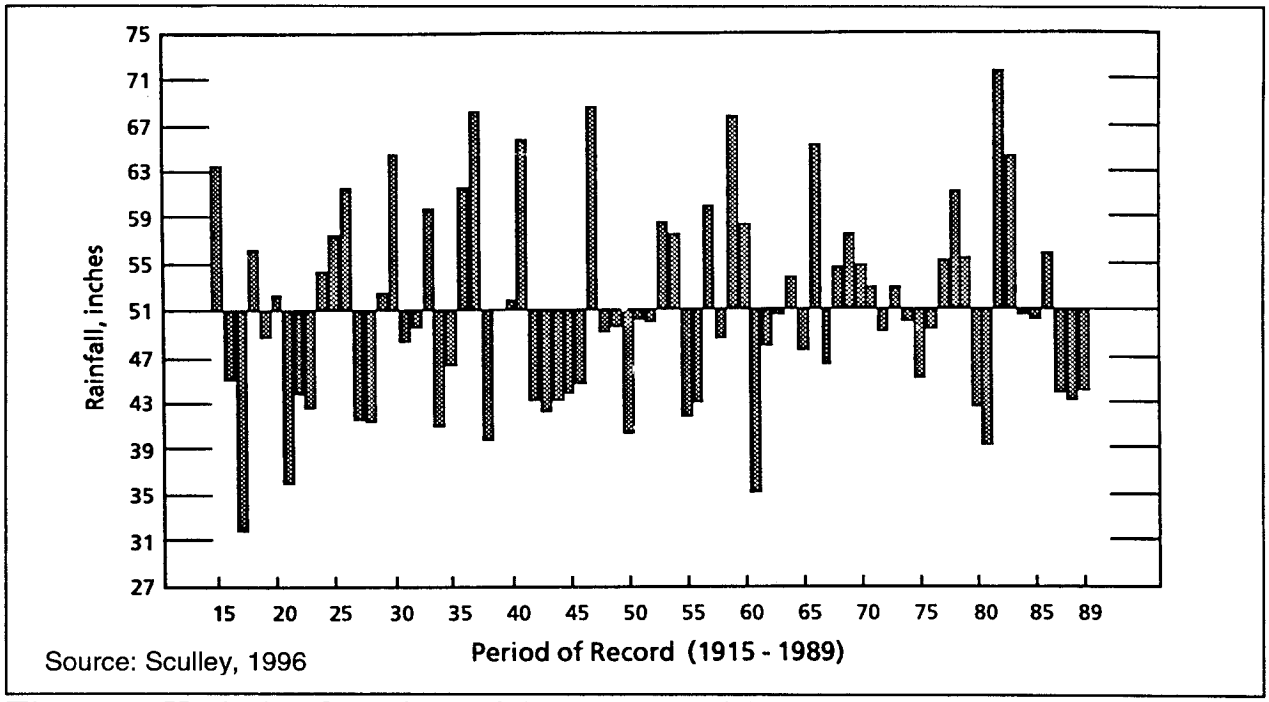


Figure 7. Variation from Annual Average Rainfall in the UEC Planning Area.

Evapotranspiration (ET) is the sum of evaporation and transpiration. Like rainfall, ET is generally expressed in inches per year. Approximately 45 inches of water per year is returned to the atmosphere by evapotranspiration in South Florida. The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average ground water recharge.

Surface Water Inflow and Outflow

Essentially all surface water inflows and outflows in the planning area are derived from rainfall. The exception to this is the St. Lucie Canal (C-44), which also receives water from Lake Okeechobee. In addition, most of the flows and stages in the region's canals are regulated for water use and flood protection. The amount of stored water is of critical importance to both the natural ecosystems and the developed areas in the UEC Planning Area. Management of surface water storage capacity involves balancing two conflicting conditions. When there is little water in storage, drought conditions may occur during periods of deficient rainfall. Conversely, when storage is at capacity, flooding may occur due to excessive rainfall, especially during the wet season. Management of surface water systems is one of the main factors affecting movement of water through the regional hydrologic cycle.

Exchange with Ground Water

Another distinctive feature of South Florida's hydrologic system is the aquifer system and its use for water supply. Two vast aquifer systems, the Surficial Aquifer System (SAS) and the Floridan Aquifer System (FAS), underlie the planning area. Ground water inflows from outside the planning area form an insignificant portion of recharge to the SAS. Rainfall is the main source of recharge to the SAS, and because of this, long-term utilization of this source must be governed by local and regional recharge rates. The FAS, on the other hand, receives most of its recharge from outside of the UEC Planning Area. This fact must also be incorporated into long-term planning decisions.

SURFACE WATER RESOURCES

Prior to development, most of the UEC Planning Area was characterized by nearly level, poorly drained lands subject to frequent flooding. The natural surface drainage systems included large expanses of sloughs and marshes such as St. Johns Marsh, Allapattah Slough (also referred to as Allapattah Flats), Cane Slough, and the Savannas (Figure 8). Drainage systems with higher conveyance included the North and South Forks of the St. Lucie River, Ten Mile Creek, Five Mile Creek, the Loxahatchee River and Bessey Creek. Most of these surface water systems, especially

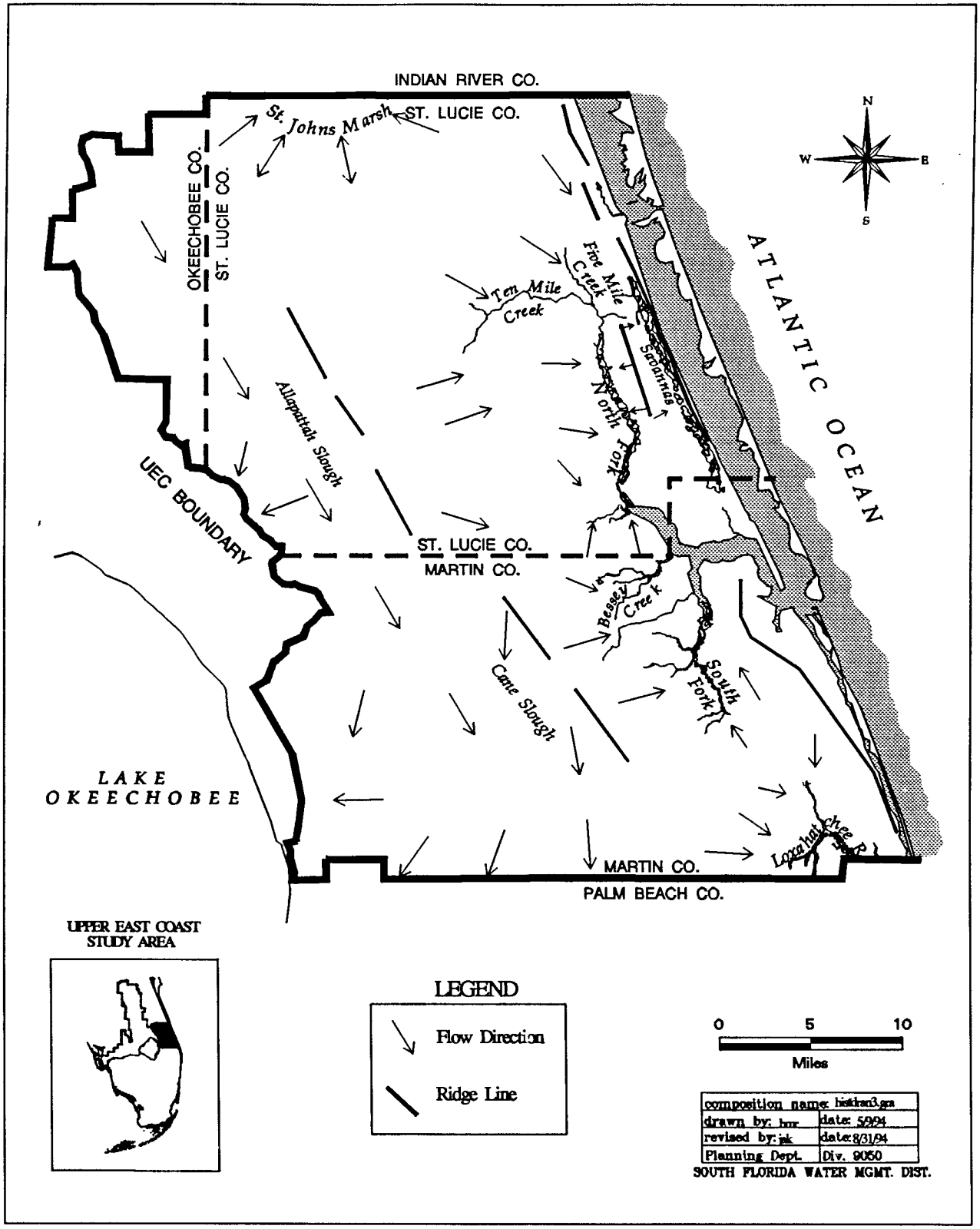


Figure 8. Historic Surface Water Drainage System in UEC Planning Area.

those with poor drainage, have been altered to make the land suitable for development and provide flood control

Since the early 1900s, numerous water control facilities have been constructed to make this region suitable for agricultural, industrial, and residential use. The St. Lucie Canal (C-44) was constructed between 1916 and 1924 to provide an improved outlet for Lake Okeechobee floodwaters. From 1918 to 1919, the Fort Pierce Farms Drainage District (FPFDD) and the North St. Lucie River Drainage District (NSLRDD) were formed to provide flood control and drainage for citrus production in east-central and northeastern St. Lucie County. The C-25 Canal (also known as Belcher Canal) provided a drainage outlet for the FPFDD, as well as limited flood protection for western areas of the basin. The C-24 Canal (also known as the Diversion Canal) provided drainage and limited flood protection west of the NSLRDD protection levee. The C-23 Canal provided water control in Allapattah Flats during the dry season. However, large areas continued to be under water for months at a time during the wet season.

Torrential rains and extensive flooding in South Florida in 1947 prompted the U.S. Congress to authorize the design and construction of the Central and Southern Florida Flood Control Project (C&SF Project). The C&SF Project included construction of levees, canals, spillways, pump stations and dams. Within the area that is now the UEC Planning Area, the project incorporated the existing canals and provided increased outlet capacity for Lake Okeechobee by making improvements to the St. Lucie Canal. The present surface water system of the UEC Planning Area, including C&SF Project structures, is shown on Plate 1.

Surface water management basins in the UEC Planning Area were first delineated in the 1950s by the U.S. Army Corps of Engineers (USACE) in their General Design Memorandum for the C&SF Project (1957). Nine basins in the planning area are served by C&SF Project works. Detailed descriptions of these basins can be found in the atlases of surface water management basins for Martin County (Cooper and Santee, 1988) and St. Lucie County (Cooper and Ortel, 1988).

There are 12 basins without Project works in the planning area. The level of flood protection in these non-Project basins varies widely, depending on the conveyance of the natural drainage system and extent of land development. Water control districts have been established in some basins to provide drainage, flood control and water supply (see Drainage Districts on page 38).

Surface Water Planning Areas

The following sections provide a description of the surface water resources for basins within the UEC Planning Area. Because adjacent basins tend to have similar needs and resources, the basins have been grouped into five geographical planning areas for the purposes of this report. These areas are the: (1) St. Lucie Agricultural Area; (2) Eastern St. Lucie Area; (3) St. Lucie River Area; (4) Southeastern Martin Area; and (5) Tidal Area (Plate 1).

St. Lucie Agricultural Area

The St. Lucie Agricultural Area is located in western St. Lucie County, eastern Okeechobee County and northern Martin County. It includes all of the C-23, C-24, C-25 basins, and parts of the North Fork St. Lucie River Basin (Figure 9).

The C-23, C-24 and C-25 canals and control structures were improved under the C&SF Project. Their current functions are: (1) to remove excess water from their respective basins; (2) to supply water during periods of low rainfall; and (3) to maintain ground water table elevations at the coastal structures to prevent saltwater intrusion.

The canals and control structures were designed to pass 30 percent of the Standard Project Flood, and to meet irrigation delivery requirements for the basin. In this planning area, a Standard Project Flood is statistically equivalent to a 10-year, 72-hour storm event. Excess water may be discharged from C-25 to tidewater by way of S-99 and S-50, or to C-24 by way of G-81. Excess water in C-24 may be discharged to tidewater by way of S-49, to C-25 by way of G-81, or to C-23 by way of G-78. Excess water in C-23 may be discharged to tidewater by way of S-97 and S-48, or to C-24 by way of G-78. A 1993 study concluded that the capacity of the C-23 was insufficient to convey design flows within the banks. Please refer to the “Canal Conveyance Capacity of C-23” report (SFWMD, 1993) for further details.

Flow in each of the C&SF Project canals is regulated by their respective control structures. For flood control and drainage, water elevations in the canal are set far enough below ground surface to provide slope in the secondary drainage systems. Water supply, on the other hand, requires the water surface in the primary canal be maintained sufficiently high to prevent overdrainage. When flow in the canals is adequate, control structures are operated to maintain a headwater stage within a seasonally dependent range (Table 6).

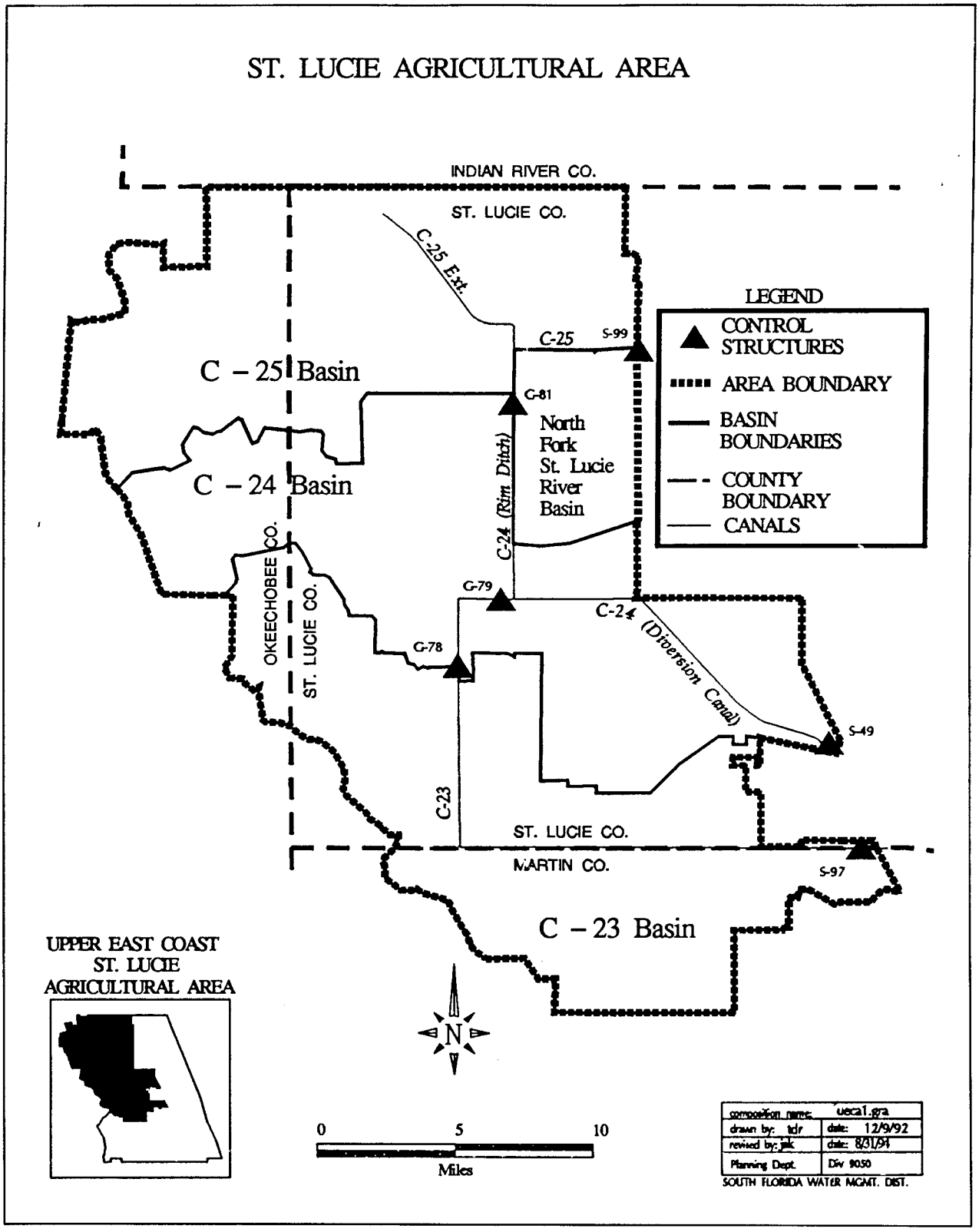


Figure 9. Drainage Basins of the St. Lucie Agricultural Area.

Table 6. Optimal Headwater Stage for Project Canals.

Canal	Structure	Headwater Stage (ft. NGVD)	
		Wet Season*	Dry Season
C-25	S-99	19.2-20.2	21.5-22.5
C-25	S-50	>12.0	>12.0
C-24	S-49	18.5-20.2	19.5-21.2
C-23	S-97	20.5-22.2	22.2-23.2
C-23	S-48	>8.0	>8.0

*Wet season is from May 15 to October 15.
Source: Cooper and Ortel, 1988.

Although the primary function of the C&SF Project was for flood control and drainage, the drainage network formed by the Project canals and the secondary canals and ditches have become an important source of irrigation water and frost protection for agriculture. In general, water stored in the canals is replenished by rainfall, ground water inflow, and runoff.

Prior to the large-scale expansion of citrus in the 1960s, storage in the drainage network in St. Lucie County was adequate to meet irrigation demands. However, the drainage and development of the large marsh areas in western St. Lucie County have depleted much of the surface water storage. The lowering of water tables have also reduced the amount of water in ground water storage. The reduction of surface and ground water storage coupled with increased acreages of citrus have resulted in inadequate supplies of surface water to meet demands during droughts. Therefore, an equitable distribution of the available surface water in the C-23, C-24 and C-25 basins is maintained by limiting the invert elevation of irrigation culverts and the intake elevation of pumps to a minimum of 14.0 feet NGVD. Artesian well water from the FAS is used as an irrigation supplement when surface water supplies become limited. Due to the high mineral content of the Floridan Aquifer, this water is generally blended with surface water before it is used as irrigation water.

Although early proposals addressed potential water supply problems in the area, local opposition and lack of funds made these efforts futile. The original General Design Memorandum envisioned a large conservation area north of C-25 in the St. Johns Marsh. The C-23, C-24 and C-25 canals and associated control structures were designed to deliver irrigation water from the water conservation area to 320 square miles of land in St. Lucie County. However, this portion of the C&SF Project was redesigned without the water conservation area due to local opposition to taking 200,000 acres of the floodplain out of production. Another proposal would have

provided a link from Lake Okeechobee to C-23. This proposed C-131 Canal and its associated control structures and pumps would have supplied irrigation water to St. Lucie County, and permitted backflow of surplus rainfall runoff from the C-23, C-24 and C-25 basins into Lake Okeechobee. The C-131 proposal was later modified to include a flowway adjacent to C-131, which was designed to improve the water quality of the backflow prior to discharging into the lake. Although the flowway would have resolved the water quality concerns, it significantly increased the cost of the project, making the overall project economically unviable.

Eastern St. Lucie Area

The Eastern St. Lucie Area includes most of the North Fork St. Lucie River Basin and all of Basin 1 (Figure 10).

There are two C&SF Project canals (C-23A and C-24) in the North Fork St. Lucie River Basin. C-23A is a short section of canal in the lower reach of the North Fork of the St. Lucie River. This canal passes discharges for both the North Fork of the St. Lucie River and the C-24 Canal to the St. Lucie River Estuary. A short reach of the C-24 Canal extends from the S-49 control structure to the North Fork of the St. Lucie River, just north of C-23A. C-23A was designed to pass 30 percent of the Standard Project Flood from the North Fork St. Lucie River Basin and from the C-24 Basin.

Two drainage districts in the Eastern St. Lucie County Area have been established to coordinate surface water management within their districts. The districts are the Fort Pierce Farms Water Control District (FPFWCD) and the North St. Lucie River Water Control District (NSLRWCD). These drainage districts are shown in Figure 15. The City of Port St. Lucie has also established the Port St. Lucie Storm Water Utility (PSLSWU).

The FPFWCD was created originally as the Fort Pierce Farms Drainage District in 1919, under the provisions of Chapter 298, F.S. and incorporates 15,000 acres of land in the basin. All canals in the FPFWCD system drain to Canal 1, which discharges to the lower reach of C-25.

The NSLRWCD was created originally as the North St. Lucie River Drainage District in 1918, under the provisions of Chapter 298, F.S. and incorporates 65,000 acres in the North Fork St. Lucie River Basin. The water control system consists of man-made canals, improved natural streams and control structures.

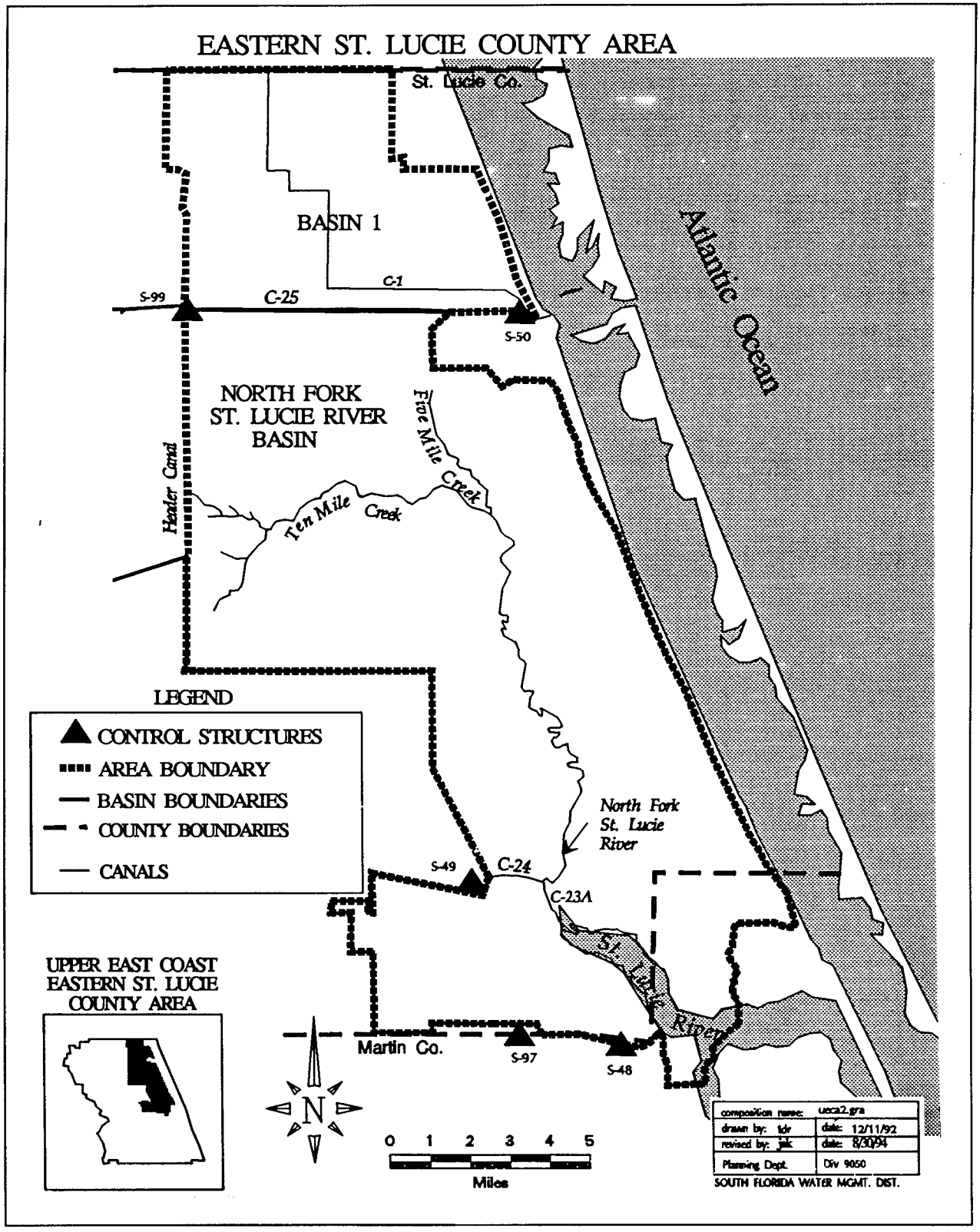


Figure 10. Drainage Basins of the Eastern St. Lucie Area.

The Header Canal is parallel to the west boundary NSLRWCD, and is located three miles east of the north-south reach of the C-24 Canal. It collects runoff from secondary canals extending westwardly, and it is connected to Ten Mile Creek to the east, C-25 to the north, and C-24 to the south. Ten Mile Creek and Five Mile Creek are natural streams which have been improved to transport water from the secondary drainage system to the North Fork of the St. Lucie River.

Water control structures in both FPFWCD and NSLRWCD are regulated on a day-to-day basis to maintain optimum canal water levels for agricultural production. During the dry season and as canal stages permit, water can be diverted from C-25 to FPFWCD for irrigation. Stage levels in the Header Canal are maintained by backpumping water from Ten Mile Creek.

St. Lucie River Area

The St. Lucie River Area covers most of Martin County (Figure 11). It can be subdivided in two categories: (1) the Canal Area which includes all of the C-44, S-153, and Tidal St. Lucie basins served by C&SF Project canals; and (2) basins 4, 5, 6, and 8. Basin 8 drains out of the UEC Planning Area and has little interaction with the St. Lucie River Area.

The Canal Area contains the only basin (C-44 Basin) in the UEC Planning Area which is hydrologically connected to Lake Okeechobee. Therefore, this section includes a discussion of the lake's regulation schedule.

Canal Area. The C&SF Project canal and control structures in the C-44 Basin have five functions: (1) to provide drainage and flood protection for the C-44 Basin; (2) to accept runoff from the S-153 Basin and discharge this runoff to tidewater; (3) to discharge water from Lake Okeechobee to tidewater when the lake is over schedule; (4) to supply water to the C-44 Basin during periods of low natural flow; and (5) to provide a navigable waterway from Lake Okeechobee to the Intracoastal Waterway. Excess water is discharged to tidewater by way of S-80 and C-44A. Under certain conditions, excess water may backflow to Lake Okeechobee by way of S-308. Regulatory releases from Lake Okeechobee are made to C-44 by way of S-308. Water supply to the basin is made from Lake Okeechobee by way of S-308 and from local rainfall. Both S-80 and S-308 have navigation locks to pass boat traffic.

Lockages are performed on an "on-demand" basis at S-80, except when water shortages have been declared or maintenance and repairs to the structure are taking place. Although there is no water shortage plan for S-80, the USACE will curtail lockages at the request of the District. Maintenance and repairs that result in stoppage of lockages are done on an as-needed basis, usually occuring every three to

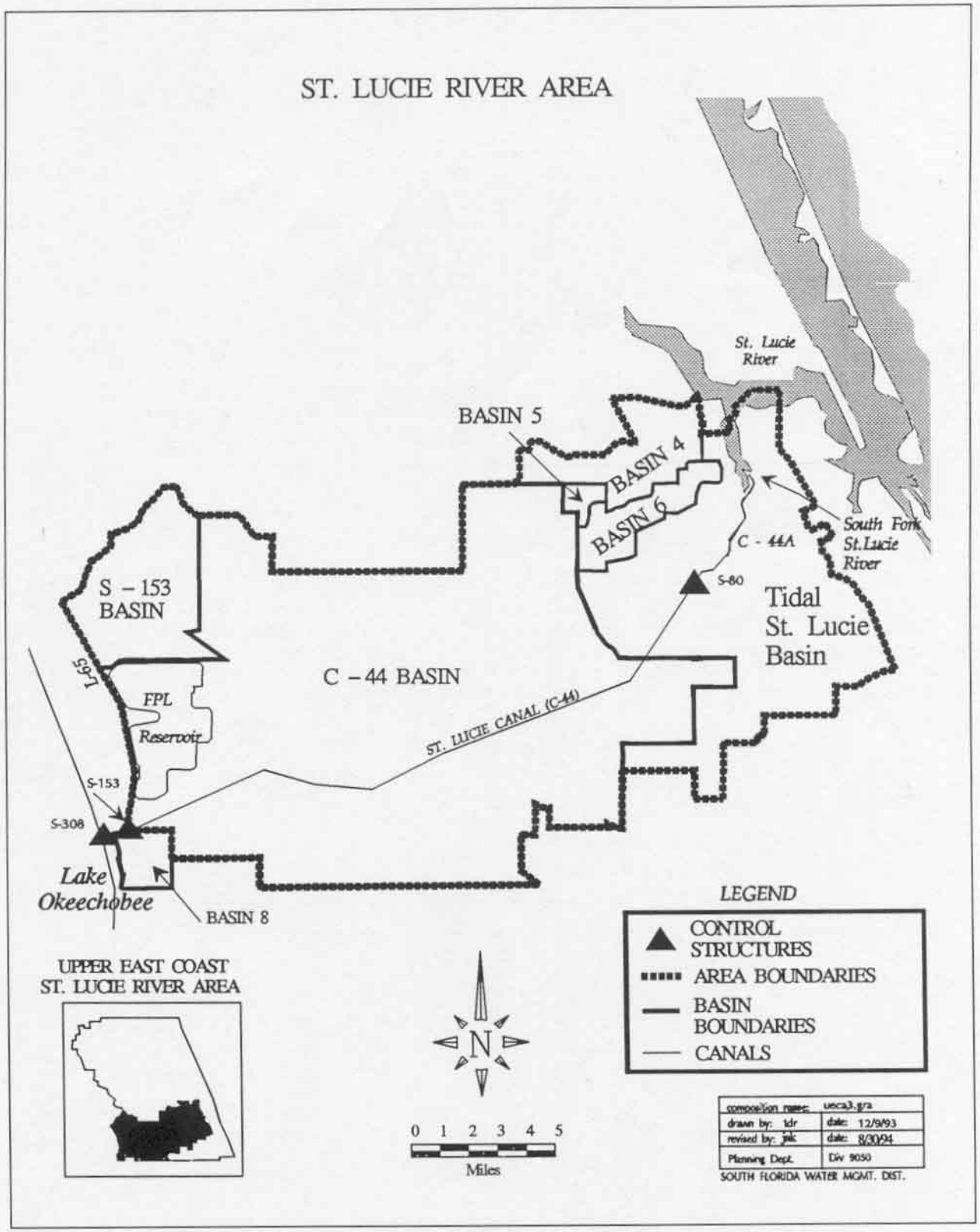


Figure 11. Drainage Basins of the St. Lucie River Area.

five years (phone conversation January 29, 1993 with Bill Mason, Lockmaster at S-80, USACE, Stuart, FL.). Each lockage at S-80 releases over 1.3 million gallons of water. The average number of lockages at S-80 vary monthly. Between 1987 and 1991, there were an average of 15 lockages per day, with maximum and minimum monthly averages ranging between 19 and 11 lockages per day (facsimile received February 1, 1993 from James Vearil, Hydraulic Engineer, USACE, Jacksonville, FL.).

The S-153 structure provides flood protection and drainage for the S-153 Basin. Excess water in the basin is discharged to C-44 by way of the L-65 borrow canal and S-153. The cooling reservoir for the Florida Power and Light power plant was originally part of the S-153 Basin. This 6,600 acre reservoir is now hydraulically connected to C-44, and is considered part of the C-44 Basin. The S-153 control structure is operated to maintain an optimum stage of 18.8 feet NGVD.

The S-80 structure in the Tidal St. Lucie Basin has three functions: (1) to accept flow from C-44 and to discharge those flows to tidewater in the St. Lucie River; (2) to provide a navigable waterway from the St. Lucie Canal to the Intracoastal Waterway; and (3) to provide drainage for portions of the Tidal St. Lucie Basin.

C-44 and S-80 were designed to pass the Standard Project Flood from the C-44 Basin and the S-153 Basin and to pass regulatory discharges from Lake Okeechobee to tidewater. The S-308 and S-80 control structures are operated to maintain an optimum canal stage of 14.5 feet NGVD within the Tidal St. Lucie Basin.

Basins 4, 5 and 6. Basins 4 and 6 are drained by Bessey and Danforth creeks, respectively. Bessey Creek discharges to the mouth of C-23, which in turn empties into the St. Lucie River. Danforth Creek discharges to the South Fork of the St. Lucie River Estuary. Basin 5 is generally landlocked, with a poor hydraulic connection to Bessey Creek. Inadequate conveyance in the drainage systems in these basins have frequently resulted in areas of inundation in flood-prone areas. See Needle (1992) for a detailed study of the Bessey and Danforth Creek drainage system.

Lake Okeechobee. Lake Okeechobee is managed as a multipurpose freshwater resource in the C&SF Project. The primary tool for managing lake water levels is the regulation schedule. This schedule defines the ranges of water levels in which specific discharges are made to control excessive accumulation of water within the lake's levee system. The schedule varies seasonally to best meet the objectives of the C&SF Project. A number of lake regulation schedules have been adopted since the construction of the C&SF Project (see Trimble and Marban, 1988). In 1978, the USACE adopted the "15.5 - 17.5" schedule, in which regulatory releases were made if lake stage exceeded 15.5-17.5 feet NGVD. A pulse release program was added in 1991, to reduce the likelihood of making large freshwater releases to the St. Lucie and

Caloosahatchee river estuaries. This schedule is commonly referred to as "Run 25" and is currently being used to regulate water levels in the lake (Figure 12).

Run 25 contains three management zones: Zone C, Zone B and Zone A, as identified by individual lines of zones shown in Figure 12. Below Zone C is three "Best Management Zones," identified as Level I, II, and III, which correspond to specific discharge criteria developed for the Caloosahatchee River and St. Lucie River estuaries, as shown in Table 7. When the lake stage falls below the Zone C line, no regulatory discharges are required. When lake stages reach Zone B or Zone A, releases of water are made by the USACE in accordance with the parameters shown in Figure 12. In Zone A, the USACE has the authority to make maximum discharges to all outlets in an effort to reduce lake levels to protect the structural integrity of the levee system from a major storm.

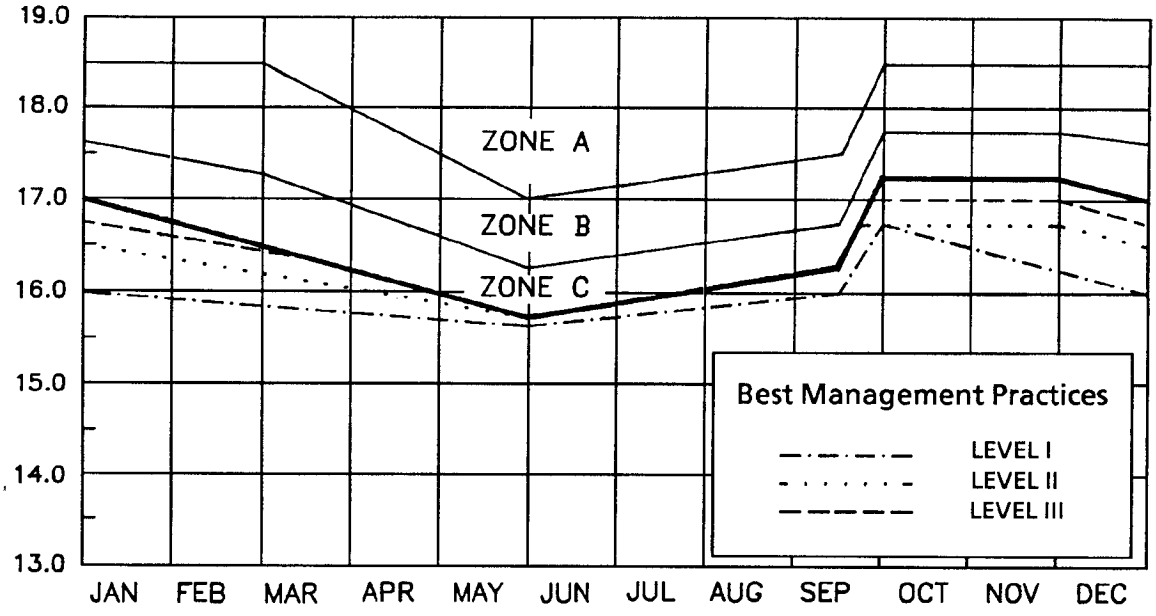
The large-scale discharges required in Zone A and Zone B are damaging to the downstream estuarine systems. The Best Management Zones below Zone C were developed to provide a buffer or safety factor for making early or pulsed releases of lake water to downstream estuaries. These release patterns are called pulse releases because they mimic the pulse release associated with a rainfall event that would normally occur in an upstream watershed of the estuary. This release concept allows the estuary to absorb the freshwater release without drastic or long-term salinity fluctuations.

Although Lake Okeechobee is a potentially large source of water, there are competing users of this water elsewhere within the Lake Okeechobee Service Area, as well as the Lower East Coast and Lower West Coast planning areas. During periods of water shortage in the lake, water supply allocations are determined through procedures described in the Lake Okeechobee Supply-Side Management Plan. This plan states that the amount of water available for use during any period is a function of the anticipated rainfall, lake evaporation, and water demands for the balance of the dry season in relation to the amount of water currently in storage.

Water availability from the lake is calculated on a weekly basis, along with a provision that allows users to borrow from their future supply to supplement existing shortfalls. The borrowing provision places the decision of risk with the user and can significantly affect the distribution of benefits among users because the amount of water borrowed is mathematically subtracted from future allocations. The Lake Okeechobee Supply-Side Management Plan is implemented if the projected lake stage falls below 11.0 feet NGVD at the end of the dry season, or below 13.5 feet NGVD at the end of the wet season (Figure 13).

LAKE OKEECHOBEE REGULATION SCHEDULE

Interim Schedule Adopted December 1991



Releases Through Outlets

Zone	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practical to WCAs	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practical to WCAs	6500 cfs	3500 cfs
C	Maximum practical to WCAs	4500 cfs	2500 cfs
Levels I, II, & III	Maximum practical to WCAs	See Table II-2 for a schedule of the pulse releases for the Caloosahatchee River	See Table II-2 for a schedule of the pulse releases for the St. Lucie Estuary

Figure 12. Lake Okeechobee Interim Regulation Schedule.

Table 7. Pulse Release Schedules for the St. Lucie and Caloosahatchee River Estuaries and their Effect on Lake Okeechobee Water Levels.

Day	Daily Discharge Rate (cubic feet per second)					
	St. Lucie Level I	St. Lucie Level II	St. Lucie Level III	Caloosa. Level I	Caloosa. Level II	Caloosa. Level III
1	1,200	1,500	1,800	1,000	1,500	2,000
2	1,600	2,000	2,400	2,800	4,200	5,500
3	1,400	1,800	2,100	3,300	5,000	6,500
4	1,000	1,200	1,500	2,400	3,800	5,000
5	700	900	1,000	2,000	3,000	4,000
6	600	700	900	1,500	2,200	3,000
7	400	500	600	1,200	1,500	2,000
8	400	500	600	800	800	1,000
9	0	400	400	500	500	500
10	0	0	400	500	500	500
Acre Feet per Pulse and Correlating Lake Level Fluctuations						
AF per pulse	14,476	18,839	23,201	31,728	45,609	59,490
Impact on lake (feet)	0.03	0.04	0.05	0.07	0.10	0.13

Source: SFWMD, 1997, Lake Okeechobee SWIM Plan.

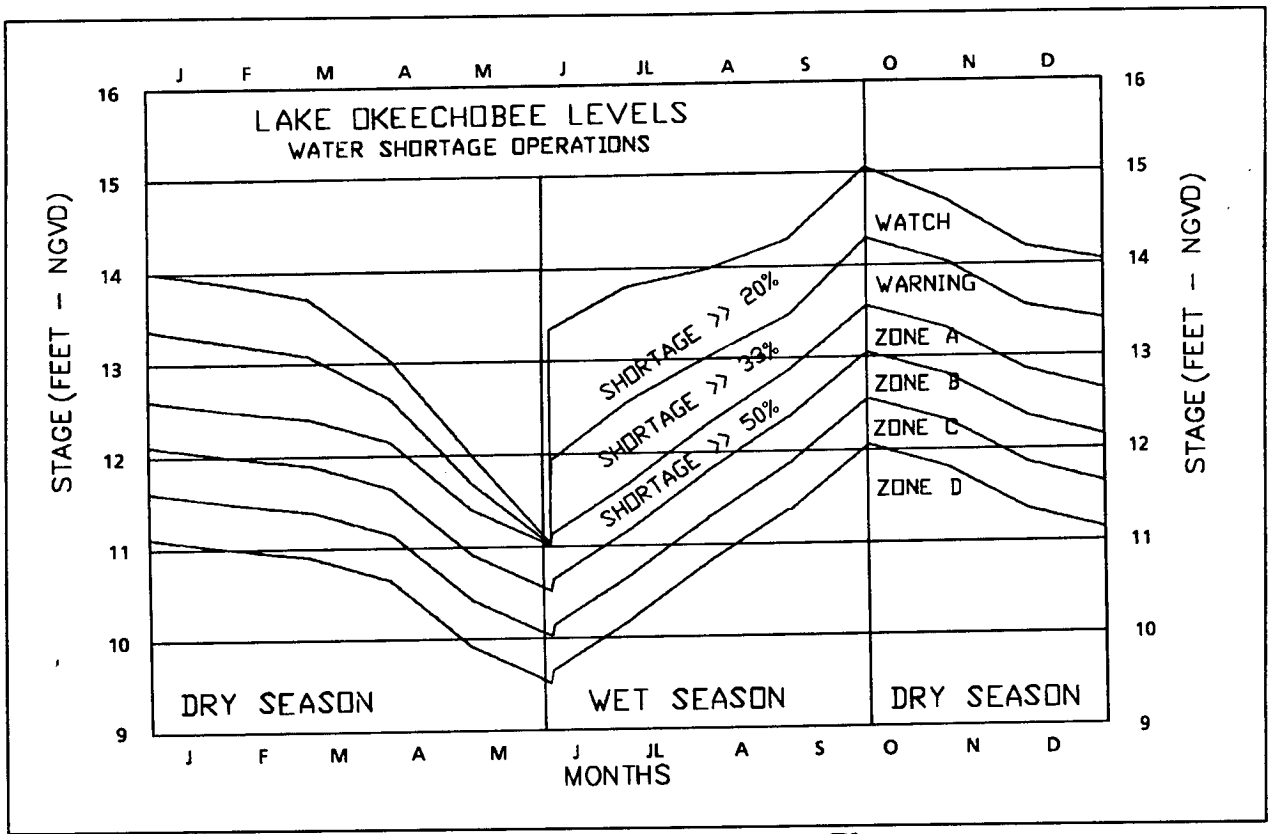


Figure 13. Lake Okeechobee Supply-Side Management Plan.

Southeastern Martin Area

The Southeastern Martin Area includes three basins: (1) Pal-Mar Basin; (2) Jonathan Dickinson Basin; and (3) Basin 2 (Figure 14).

The Pal-Mar Basin contains wet prairie ponds and pine flatwoods, portions of which are being acquired through land various acquisition programs (see Chapter 3, Environmental Resources and Needs). This basin does not drain to adjacent basins except through sheetflow during heavy rainfall. When this occurs, the Pal-Mar Basin overflows to the North Fork of the Loxahatchee River via Cypress Creek.

The Jonathan Dickinson Basin is a state park bounded by the Coastal Ridge to the east, which is vegetated with sand pine scrub, pine flatwoods, and a mixture of wetland types. The basin drains to the Loxahatchee River located in the southern half of the basin. The sandy coastal ridge soils produce little surface water runoff as a result of high infiltration rates.

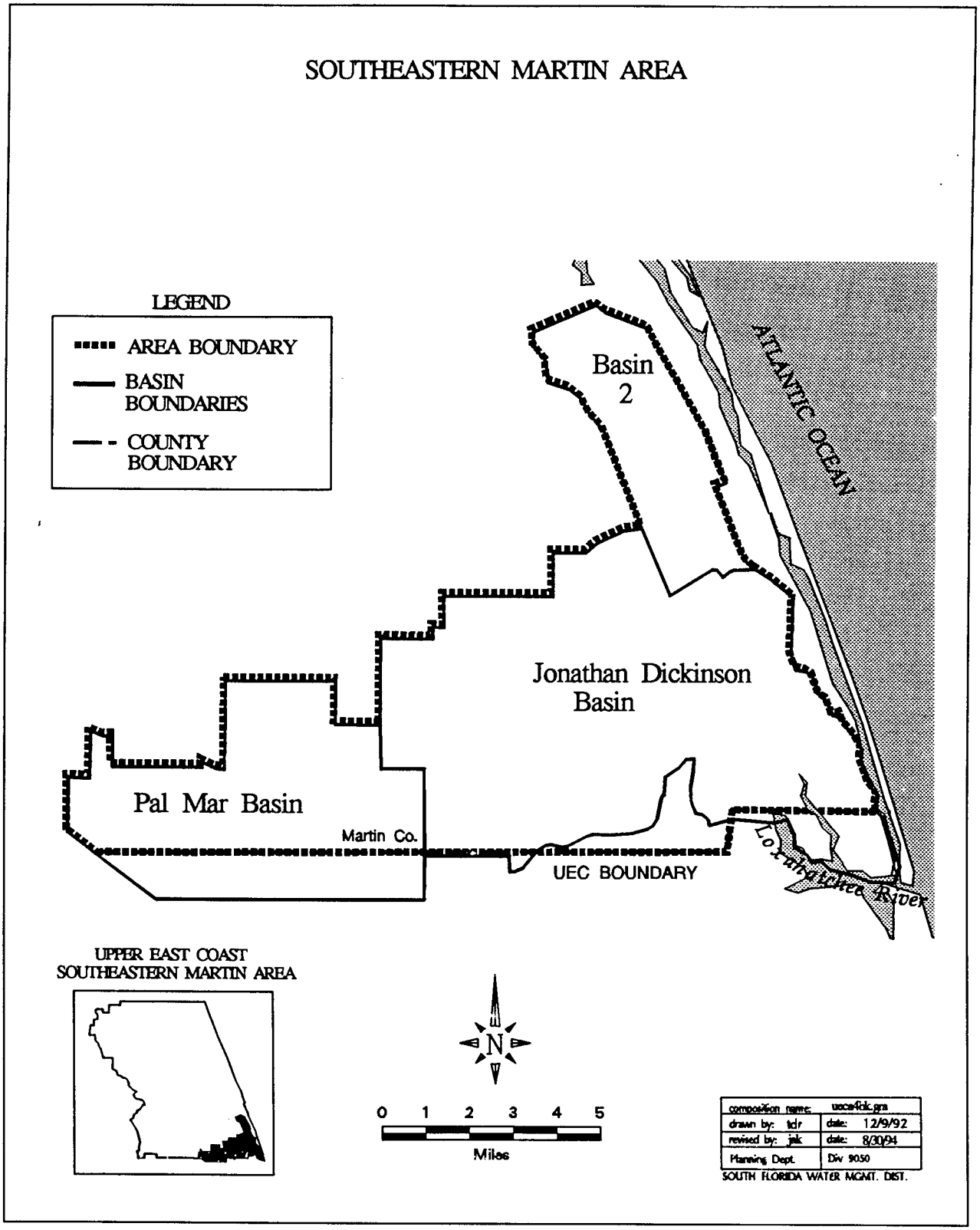


Figure 14. Drainage Basins of the Southeastern Martin Area.

Basin 2 is bounded by the coastal ridge to the east and pine flatwoods to the west. The basin has poorly defined internal drainage, and about one-third of the basin drains north to the Manatee Pocket, which is part of the St. Lucie River/Indian River Lagoon estuarine system.

Tidal Area

There are three basins within the Tidal Area: (1) North Coastal; (2) Middle Coastal; and (3) South Coastal. These basins are located in coastal St. Lucie and Martin counties. In general, these basins contain barrier islands, the Intracoastal Waterway, and mainland beaches. Most of the surface water in these basins is tidal.

Drainage Districts

Chapter 298, Florida Statutes governs local water control districts. These 298 districts (Figure 15) are empowered to develop and implement a plan for draining and reclaiming the lands, and control all water movement within their jurisdiction. The 298 districts have the power to construct and maintain canals, divert flow of water, construct and connect works to canals or natural watercourses, and construct pumping stations. They may also enter into contracts, adopt rules, collect fees, and hold, control, acquire or condemn land and easements for the purpose of construction and maintenance.

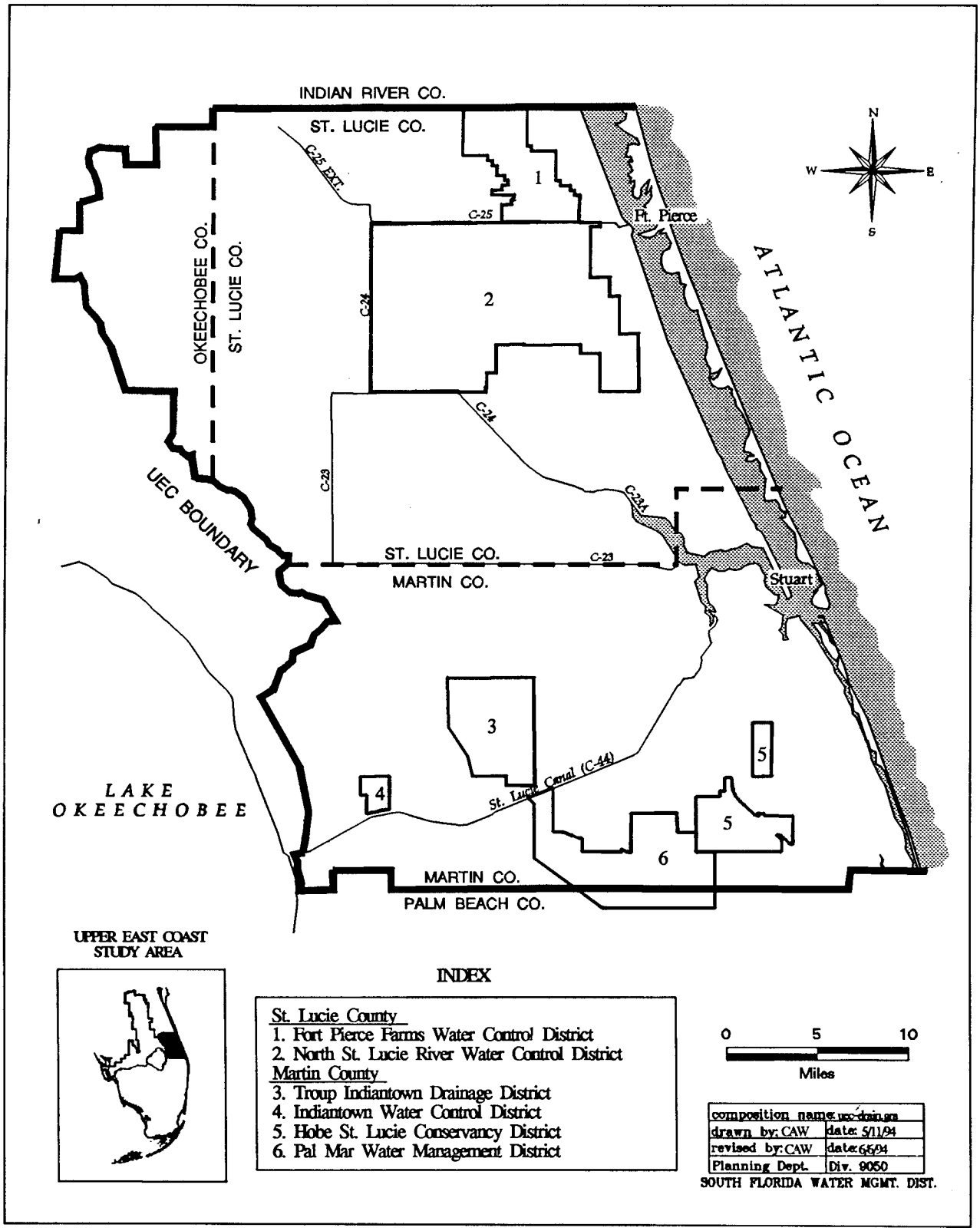


Figure 15. Chapter 298 Drainage Districts.

GROUND WATER RESOURCES

The hydrogeology of South Florida is diverse. It includes aquifers which are confined (in which ground water is under greater than atmospheric pressure and isolated from vertical recharge), semi-confined (having some vertical recharge), and unconfined (ground water is at atmospheric pressure and water levels correspond to the water table). Within an individual aquifer, hydraulic properties and water quality may vary both vertically and horizontally. Because of this diversity, ground water supply potential varies greatly from one place to another. It is the purpose of this section to identify the aquifers in the region, and describe their current usage and water producing capability.

The two major aquifer systems, the Floridan Aquifer System (FAS) and the Surficial Aquifer System (SAS), are summarized in Tables 8 through 10 for Martin, St. Lucie, and Okeechobee counties. Appendix D includes a collection of ground water resources graphics. Table D-1 outlines the temporal and physical relationships between these different aquifer systems. In addition, a stratigraphic cross section (Figure D-1), and maps showing the elevation and thickness of each of the hydrogeologic units (figures D-2 to D-5) are provided in Appendix D. Ground water flow models used to evaluate hydrogeologic systems and identify problem areas are discussed in Chapter 10.

Table 8. Ground Water Systems in Martin County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	100-250	Principal source of fresh water for public and agricultural water supply. Yields moderate amounts of water. Water quality is generally fair, with areas of high iron, hardness, and/or total dissolved solids.
Intermediate Confining Unit	Hawthorn Confining Beds	400-650	Does not produce significant quantities of water within Martin County.
Floridan Aquifer System	Floridan Aquifer	2,900-3,400	Confined aquifer. Yields moderate to large amounts of water. Requires desalination for potable uses, but is suitable for irrigation purposes in the northern part of the county when mixed with surface water. Water quality deteriorates toward the south, and with increasing depth.

Table 9. Ground Water Systems in St. Lucie County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	90-150	Principal source of fresh water for public water supply. Yields small amounts of water. Water quality is fair to good, with localized areas of high iron, chlorides, and/or dissolved solids.
Intermediate Confning Unit	Hawthorn Confining Beds	400-700	Does not produce significant quantities of water within St. Lucie County.
Floridan Aquifer System	Floridan Aquifer	2,700-3,100	Confined aquifer. Requires desalination treatment for potable use, but is suitable for most irrigation purposes when mixed with fresh surface water. Water quality deteriorates with increasing depth.

Table 10. Ground Water Systems in Eastern Okeechobee County.

Hydrogeologic System	Hydrogeologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Surficial Aquifer	10-180	Principal source of fresh water for residential self-supply in unincorporated areas. Yields small amounts of water. Water quality is generally good, except near Lake Okeechobee where chloride concentrations exceed potable standards.
Intermediate Confining Unit	Hawthorn Confining Beds	200-600	Does not produce significant quantities of water within Okeechobee County.
Floridan Aquifer System	Floridan Aquifer	2,700-3,000	Confined aquifer. Yields moderate to large amounts of water. Primary source of supply for agricultural uses. Water quality is very good in the north, but deteriorates to the south and east and with increasing depth.

Surficial Aquifer System

The SAS is the principal source of water for urban uses, including potable water, within the UEC Planning Area. It includes all saturated rock and sediment from the water table to the top of the underlying intermediate confining unit. Geologically, this includes the Pamlico and Anastasia formations and part of the Tamiami formation. Over most of the planning area, the aquifer is composed primarily of sand interbedded with thin beds or lenses of limestone, sandstone, or shell.

The lithology, and consequently the productivity of the aquifer, varies both laterally and vertically. Producing zones are not always found at the same depth within the aquifer, and may be missing entirely. In general, the permeable limestone, sandstone and shell strata are more prevalent in the eastern than western part of the counties (Lichtler, 1960). Productivity and water quality in the aquifer also tend to improve from north to south and west to east.

Upper Confining Unit for the Floridan Aquifer System

Within the UEC Planning Area, the upper confining unit for the FAS is comprised of the relatively impermeable sequence of phosphatic clays, silts and limestones of the Hawthorn group. The top of the confining beds lies around -80 feet NGVD in the northwest corner of St. Lucie County. It dips gently to the southeast, reaching a maximum depth of over -200 feet NGVD in southeastern Martin County. Thickness also varies, ranging from less than 300 feet in northern St. Lucie County, to more than 600 feet at the extreme southern end of the planning area.

Floridan Aquifer System

The FAS, which underlies all of Florida and portions of southern Georgia and Alabama, ranges in thickness from 2,700 to 3,400 feet within the planning area (Scott *et al*., 1991). The top of the FAS lies around -300 feet NGVD in the northwest corner of the planning area, then dips to the southeast to more than -900 feet NGVD in southeast Martin County. Parker *et al*. (1955) designated the FAS to include "parts of the middle Eocene (Avon Park and Lake City Limestone), upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone, and permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer)."

Within the FAS are multiple permeable intervals, or producing zones, sandwiched between low permeability confining materials. The permeable intervals are associated with solution cavities and formational unconformities, the latter of which can be correlated over large areas (Brown and Reece, 1979). Tibbals (1991) divided the FAS into two aquifers based on the vertical occurrence of two highly permeable zones. These are the upper Floridan and lower Floridan aquifers. They are separated by a low permeability interval named the middle semi-confining unit. The term lower Floridan, as it appears here, refers to the upper portion of the lower Floridan aquifer. This zone shall henceforth be referred to as the upper part of the lower Floridan aquifer. This terminology and the geologic description of the FAS which follows were adopted from Lukasiewicz (1992).

The FAS is an important source of agricultural irrigation water, particularly in the northern portion of the planning area. The FAS, however, requires desalination treatment in order to supply potable uses. The quality of water in the FAS deteriorates to the south, increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less suitable for development than those near the top of the system.

Upper Floridan Aquifer

The upper Floridan aquifer (UFA) is the principal source of supply to users of the FAS in the planning area. It is approximately 500 feet thick, and characterized by two distinct and continuous producing zones. These two zones occur along the unconformities which serve as the lithologic contacts between the Suwannee formation and the Ocala Group, and the Ocala Group and the Avon Park formation. There are also numerous high permeability zones created by solutioning and dolomitization (the replacement of calcium carbonate with magnesium carbonate). These zones are not stratigraphically controlled, and occur irregularly throughout the planning area.

The UFA is an important source of irrigation water for agriculture in St. Lucie County and to a lesser extent in Martin County. Floridan wells, which flow without pumping, produce large volumes of relatively poor quality water. UFA water averages about 900 mg/L total dissolved solids in St. Lucie County, and deteriorates toward the southeast to 3,000 mg/L in southeastern Martin County. Because of its poor quality, ranchers and grove operators tend to discharge Floridan water into irrigation ditches, where it mixes with better quality surface water and ground water from the SAS. This dilutes the brackish Floridan water to a level acceptable for agricultural irrigation, and allows growers to supplement their surface water supplies when availability is limited.

Where chlorides are sufficiently low, upper Floridan water can be blended with SAS water for use by public water supplies (i.e., Fort Pierce Utilities Authority). In most cases, however, desalination treatment will be necessary to provide potable quality water. Martin County Utilities and the Town of Jupiter, as well as numerous development communities along the coast, are currently using, or have immediate plans to use desalinated UFA water to supply their service areas. The productivity of the UFA is considerably greater than that of the SAS throughout most of the planning area, although a structural feature which is approximately aligned with the Intracoastal Waterway results in reduced productivity along the coastal margin north of Vero Beach. Overall, chlorides are within a reasonable range for current desalination technologies. It is expected that, as the area continues to grow, use of the UFA for augmenting urban supply will increase.

Middle Semi-Confining Unit

The middle semi-confining unit, corresponding stratigraphically to the Avon Park Formation, is composed of chalky calcilucite interbedded with limestones and dolomites. Because few wells in the planning area fully penetrate this unit, data on its variability is limited. Data from a few test wells in the planning area place its thickness at 200 to 400 feet.

Upper Part of the Lower Floridan Aquifer

The deeper producing zones of the FAS are associated with the Lake City Limestone, a hard, porous, crystalline dolomitic limestone, with stringers of chalky fossiliferous limestone.

There are two distinct flow zones within the upper part of the lower Floridan aquifer (ULFA), one at the contact between the Lake City Limestone and the Avon Park Formation, and a deeper one where the Lake City Limestone contacts the Oldsmar formation. In this document, these flow zones are referred to as Lower Floridan Aquifer Production Zones 1 and 2. Borehole geophysical logs and drill stem tests performed at two test wells in the planning area indicate the permeability of the two zones is cavernous in nature. The zones are separated by approximately 250 feet of low permeability material.

The two producing zones may also be distinguished by a significant difference in water quality. Water samples collected from a test well in central St. Lucie County showed TDS levels between 1,100 to 1,200 ppm in the upper producing zone, and 2,000 or more in the lower zone.

Although very transmissive zones have been documented within the ULFA, they are generally not used as supply sources within the UEC Planning Area due to the high salinity and mineral content of their water and high drilling costs. Most interest in this portion of the FAS lies in its potential for use in aquifer storage and recovery (ASR) projects (see Chapter 8). This portion of the lower Floridan has been determined to have high potential for ASR due to its capacity for receiving and storing large quantities of injected water (Lukasiewicz, 1992).

Directly below the ULFA lies an extremely thick confining interval of dense limestones and dolomites which effectively preclude flow between the ULFA and the Lower Floridan Aquifer. An area of extremely high transmissivity, known as the "boulder zone," occurs at the base of the lower Floridan aquifer. In South Florida the boulder zone has been used for disposal of treated wastewater effluent and reject water/concentrate from reverse osmosis water treatment facilities.

SURFACE WATER/GROUND WATER RELATIONSHIPS

In the preceding sections, surface water and ground water resources have been addressed as separate entities. In many ways, however, they are highly interdependent. The construction and operation of surface water management systems affect the quantity and distribution of recharge to the SAS. Although a major source of water supply, in terms of their interaction with ground water, surface water management systems within the planning area function primarily as aquifer drains. Adams (1992) estimated that 19 percent of ground water flow in Martin County is discharged into surface water bodies, while only one percent of aquifer recharge is derived from surface water sources. Surface water management systems also impact aquifer recharge by diverting rainfall from an area before it has time to percolate down to the water table. Once diverted, this water may contribute to aquifer recharge elsewhere in the system, supply a downstream consumptive use, or it may be lost to evapotranspiration (ET) or discharged to tide.

Although the FAS is not hydraulically connected to surface water within the planning area, FAS water is usually diluted with surface water to achieve an acceptable quality for agricultural irrigation. Consequently, surface water availability for dilution purposes can be a limiting factor on the use of FAS water.